

N800/ST-108

U.S. PATENT APPLICATION OF

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relating to

PORTABLE CONVERGENT SPRAY GUN CAPABLE OF BEING HAND-HELD

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### Description

## PORTABLE CONVERGENT SPRAY GUN CAPABLE OF BEING HAND-HELD

### Cross References

- 5                    This invention relates to the subject matter disclosed in a contemporaneously filed co-pending patent application that is entitled "Convergent Spray Shut-Down System" by Scarpa et al, and which is commonly assigned, identified by Attorney Docket No. N804/ST-111 and incorporated herein by reference.

### 10                    Technical Field

                    This invention relates to portable convergent spray guns for applying coatings to a surface and particularly to a portable spray gun that is miniaturized so as to be capable of being hand-held or having the option of being either hand-held or robotically-held for use with a portable system.

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**Background of the Invention**

U.S. Patent Nos. 5,564,241 granted to Mathias et al on October 15, 1996 entitled "Convergent End Effector" and 5,579,998 granted to Hall et al on December 3, 1996 entitled "Method For Coating A Substrate With A Reinforced Resin Matrix" of which the inventor Jack G. Scarpa is a co-inventor and which these patents and this patent application are commonly assigned. Both of these references disclose a spray gun that utilized a nozzle that is designed to configure the spray emitted by the nozzle into an atomized convergent plume of liquid resin and targets the plume with reinforced filler material downstream of the nozzle to mix and wet the filler just prior to being applied to the surface of the substrate. In other words the reinforcing material is entrained around the atomized liquid resin flow and is caused to be captured thereby, mix therewith and become an homogeneously wetted coating material that after impact with the substrates becomes cured into a substantially reasonably thick coating exhibiting good strength and resistance characteristics. The gaseous transport stream together with the eductor deliver the ingredients in the proper proportions and the air stream for causing the atomization and mixing to provide the proper amounts of material to assure that the coating is uniform and consistent. Heating is applied in the

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proper sequence to assure that the viscosity is at the proper level to assure evenness of flow and better atomization.

As one skilled in this technology would appreciate, the heretofore known spray application equipment for spraying of highly loaded paints and coatings which require the addition of a high volume of solid large granular materials such as cork, glass microspheres, granular or powdered materials in the 3 to 300 microns range require large amounts of solvents to dilute solid contents down to a level where it can be sprayed effectively. This, of necessity, requires special spray equipment designs that need to be significantly large in order to effectively spray these materials. Such systems have heretofore been designed to operate in a room or compartment that include a robot that was programmed to hold the spray gun and apply the spray. An additional room housed the supply of materials to be mixed and sprayed, the various valves, hoppers, proportioning devices and the like and separated from these rooms was a room that housed the computer equipment that served to control the various valves, proportioning devices etc, to automatically effectuate the spraying.

Co-pending patent application serial No. 08,/994,768 filed by Scarpa et al on December 19, 1997 entitled "Portable Convergent Spray Gun For

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Applying Coatings" and also commonly assigned, exemplifies a convergent spray gun that is made into a portable unit. Like the spray guns described in the aforementioned patents which are typically held by a robot, it, likewise, is very large and as a matter of fact requires the spray apparatus to be formed  
5 as part of a wand that requires two hands to operate effectively.

These special very large spray equipment designs leads to very low actual transfer efficiencies for spraying these coating materials. These low transfer efficiencies have a significant impact on the quantities of materials, solvents and volatile organic compounds that are released into the  
10 environment. As one skilled in this technology will appreciate, from an ecology standpoint these conditions are not preferred as is recognized by the Environmental protection Agency and Occupational Safety and Health Administrations that are tightening regulations that mandate change.

While one would normally expect that in order to reduce the size of  
15 the gun and attain all of the features and particularly be able to apply the same amount of coating for each pass, one would merely have to reduce the size of each of the components of the heretofore known guns as for example, of the type exemplified in the aforementioned patents. However, merely reducing the size of the components will not realize a convergent spray gun that will

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effectively spray a coating and as a matter of fact such a design fails to meet the specifications for coatings that are required in the larger guns that are exemplified by the aforementioned patents and patent application. As a matter of fact, we have found that it was necessary to add additional components in order to reduce the overall size and weight of the gun so that it could be hand-held, that is, held by one hand in the same way that a commercially available paint spray gun is handled. This invention contemplates adding a concentric tube construction to the commercially available (modified to meet the needs of the present invention) spray nozzle, such as spray nozzles produced by Binks, Fanklin Park, Ill and Graco, Detroit, Michigan that provides an inner tube that transports the resin and an outer tube that transports the air for atomizing the mixture and the dry powdered nozzle and its convergent cap. This arrangement of the concentric tubes allows the dry powdered nozzle that transports the dry powder material into a manifold to be propelled into the resin/air atomization plume. The dry granular materials and atomized resins become entrained at this point and thoroughly mix together outside the gun before being deposited on the substrate.

As is the case of the structure in the U.S. Patent No. 5,307,992 granted to Hall et al on May 3, 1994 entitled "Method And System For

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6) Enhanced ability to apply coatings to smaller parts and enclosures;

(7) Ability to reduce the required passes to attain the desired thickness;

5 (8) Significant reduction in waste and hazardous materials.

(9) Significant reduction in solvents; and

(10) Ability to control density.

#### Summary of the Invention

10 An object of this invention is to provide an improved mini-convergent spray gun that is characterized as being capable of being held in the user's hand.

15 A feature of this invention is that it incorporates a concentric tube assembly communicating with a commercially available spray gun that transports the resin and air to a reduced sized dry powdered nozzle and convergent end-effector for injecting a dry powder in the convergent atomized resin spray at the exterior of the resin discharge orifice.

A still further object of this invention is to provide a convergent type of spray gun that is capable of being hand-held that is characterized as being



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capable of thermal protection coatings with the absence of a solvent, and is compatible with epoxy, silicone, polyurethane, silicate, water based or 100% resin systems; has the capability of controlling the thickness and the dimensions of the area of the applied coatings; has the ability to control both  
5 dry filler and resin filled material independently; to apply the coatings to smaller parts and enclosure and reduce the number of passes to attain the desired thickness of the coating, reduce the amount of hazardous materials and solvents while being capable of controlling density.

The foregoing and other features of the present invention will become  
10 more apparent from the following description and accompanying drawings.

#### Brief Description of the Drawings

Fig. 1 is a perspective view of the miniaturized spray gun of this invention;

15 Fig. 2 is an exploded view showing the component parts of the invention comprising the miniaturized convergent spray gun of Fig. 1;

Fig. 3 is a diagrammatic view in section of the concentric tube assembly of this invention;

Fig. 4 is a partial view partly in section and partly in elevation taken

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along the longitudinal axis of the concentric tubes of Fig. 1:

Fig. 5 is plan view of the front end of the dry powdered nozzle of the spray gun depicted in Fig. 1;

Fig. 6 is a plan view of the aft end of the dry powdered nozzle of the spray gun depicted in Fig. 1;

Fig. 6A is a sectional view of an alternate embodiment of the dry powdered nozzle for use with the spray gun depicted in Fig. 1;

Fig. 7 is a perspective view of the spray gun depicted in Fig. 1 and a schematic illustration of the system utilized therewith;

Fig. 8 exemplifies another version of this invention shown in an exploded view of a prototype portable miniaturized convergent spray gun configuration; and

Fig. 9 is an alternate embodiment of the portable spray gun that is substantially the same as the embodiment depicted in Fig. 8 save for the fact that this embodiment is straight through.

These figures merely serve to further clarify and illustrate the present invention and are not intended to limit the scope thereof.

#### Best Mode for Carrying Out the Invention

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As noted in the above paragraphs, the system for supplying the desired ingredients for the coating is described in Patent No. 5,307,992, supra and the system for supplying these ingredients to the spray gun of this invention is substantially the same. In one version, the resin and catalysts  
5 (resin) are mixed in the paddled mixer that is disposed in the gun and in the other version the resin and catalyst are mixed in a static mixer disposed upstream of the spray gun and both system will be fully described hereinbelow. The dry materials such as cork or glass micro spheres are transported by a controlled dry hopper loss-in-weight or mass loss feeding  
10 system that feeds into educted pneumatic tubes that transports the material to a cyclonic mixer and then to the Convergent End-Effector nozzle. The wet epoxy resin material such as 3M 2216 which is commercially available or other suitable epoxy or polyurethane systems of various ratio is transported by means of pressure pots. The components of the resin is regulated to a  
15 desired ratio by a suitable commercially available proportioning system. Such systems are available, for example, from the Zenith Pump division of Parker Hannifin Corporation of Sanford, North Carolina or from the Moyno division of Robin & Myer of Dayton, Ohio. These proportioning systems or any other type of commercially available proportioning systems that are usable in this

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system are designed to proportion the two components of the resin and meter the same to a suitable mixer either of the dynamic or static type prior to being flowed to the discharge nozzles of the spray gun. The system serves to control all the valves, air and resin flows by a suitable analog panel which is controlled  
5 by a suitable I/O control processor of a general purpose type of computer. To better understand this invention the nomenclature of the component parts are defined as follows:

10 Convergent End Effector nozzle - is the discharge end of the gun where the resin and air are atomized and converged and the dry powder is introduced through the dry powdered nozzle.

Dry powdered nozzle is the nozzle that feeds the dry powder into the plume of the atomized resin.

Convergent cap is the cap mounted on the end of the dry powdered nozzle that defines the discharge orifice.

15 Nozzle is any discharge orifice that discharges flow in a prescribed manner.

The invention can best be understood by referring to Figs. 1-7 which shows the convergent spray gun generally illustrated by reference numeral 10 as being comprised of a commercially available Binks gun or of the type of  
20 gun described in U. S. Patent No. 2,971,700 granted to Peeps on February 14, 1961 entitled "Apparatus For Coating Articles With Chemically Reactive

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Liquids" (which is incorporated herein by reference) generally illustrated by reference numeral 12 and modified for meeting the requirements of this invention, the dry powered nozzle 14 and the concentric tube assembly generally illustrated by reference numeral 16. The commercially available

5 Binks gun which essentially is an L-shaped main body 17 having appropriate passages for flowing the air and resin to a convergent nozzle 19 is modified to accommodate this invention by including a receiving box 18. Receiving box 18 includes fittings for transmitting air into inlet 20 and then into the inlet 21 of the spray gun 10, fittings for transmitting the dry powder into inlet 22

10 where it is split by any type of splitter (not shown) into two streams for flowing the dry powder through the discharge fittings 23 and 25 and the valve 24 (see Fig. 3). Trigger 30 is suitably mounted adjacent the handle 31 and is conveniently available for operation for actuating the gun to turn the spray of coating on and off. The fitting 38 serves to receive the mixed resin delivered

15 thereto from a suitable pressurized source and flows through a passage formed in the spray gun 10 and discharges through the central orifice 26 as will be described in detail hereinbelow. In addition to the modification of the Binks gun described above, a fluid tip of the type known as a Paasche tip that is commercially available and as best seen in Fig. 3 is designed to include valve

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24 that is manually operated by the trigger 30. Valve 24 may be located adjacent to the central orifice 26 discharging the resin and includes seat 28 surrounding the orifice 26 and the valve body 27 connected to the valve stem 29 for rectilinear movement by actuation of the trigger 30 for opening and closing the discharge orifice 26 of the spray gun 10. Alternatively the valve 24 may be located adjacent to orifice 40. In the alternative embodiment the same or similar parts constituting the valve mechanism would be utilized in this location.

Referring next to Figs. 4-6, the dry powdered nozzle 14 mounted on the concentric tube assembly 16 includes a pair of diametrically opposed fittings 32 and 34 adapted to receive suitable tubing for conveying the dry powder flowing through the fittings into the manifold of the dry powered nozzle that will be described hereinbelow.

As was mentioned above, the L-shaped spray gun 10 is capable of being miniaturized from the heretofore known convergent spray guns not merely because the components are made smaller, which is partially the case, but because of the modification to the Binks type of gun and the addition of the inner and outer extension tubes of the concentric tube assembly 16 which will be described in more detail hereinbelow. As best seen in Fig. 3, the

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modified Binks gun 12 includes the central orifice 40 that is fluidly connected to the inlet of the fitting 38 for flowing the resin toward the discharge end of the spray gun. The outer tube 42 includes a large diameter hollow conically shaped portion 44 that fairs into a smaller diameter tubular portion 46 that

5 extends axially toward the fore end of the spray gun. The aft end of the outer tube 42 is threadably connected to the end of the modified Binks gun by the complementary threads 49 so that the cavity 48 defined by the conically shaped large diameter portion 44 surrounds the tip 50 of the modified Binks gun. Inner tubular member 58 is threadably attached to the outer tube 44 by

10 the complementary threads 52 and, like the tubular portion 46 of the outer tube 42, extends axially toward the tip of the spray gun 10 and lines up with orifice 40 of nozzle 19 to continue the flow of resin toward the central discharge orifice 26. As is apparent from the foregoing the resin is transported toward the tip of the spray gun 10 through the inner tubular member 58 and

15 atomizing air discharging from the circumferentially spaced air discharge holes 60 and 62 of the Binks gun is transported through the outer tubular member 42 via the centrally disposed drilled passages 64 and the annular passage 66.

The tip of the spray gun 10 is defined by the fluid tip element 70 that includes a central passage 72 terminating in a discharge central orifice 26 and the air

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$37^{\circ}$   $35^{\circ}$   $33^{\circ}$   $31^{\circ}$   $29^{\circ}$   $27^{\circ}$   $25^{\circ}$   $23^{\circ}$   $21^{\circ}$   $19^{\circ}$   $17^{\circ}$   $15^{\circ}$   $13^{\circ}$   $11^{\circ}$   $9^{\circ}$   $7^{\circ}$   $5^{\circ}$   $3^{\circ}$   $1^{\circ}$

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discharge end of central orifice 84 so that the resin flowing through passage  
68  
88 into the reduced diameter portion of central passage 86 to increase the  
dynamic head of the resin and cause it to be accelerated and expand as it is  
being discharged. The air discharging from the convergent surface 92 of air  
5    a    cap is formed in a highly atomized spray <sup>that</sup> the mixes intensely with the resin as  
it discharges from orifice 84 and forms a stream of small particles accelerating  
toward the target. The mixed atomized air and resin are discharged so as to  
define a plume immediately downstream of the central aperture 98 formed in  
the air cap 90 where the dry powder is injected as will be explained  
10    hereinbelow.

The dry powdered nozzle 14 as shown in Figs. 4-6 consists of a main  
cylindrically shaped body 102 having angularly disposed extension portions  
104 and 106 and includes a central straight through bore 109 communicating  
with the drilled passages 108 and 110 angularly disposed relative thereto  
15    formed in the extension portions 104 and 106, respectively. The dry powdered  
nozzle 14 is fitted over the sleeve <sup>106</sup> ~~110~~ that is concentrically and coaxially  
disposed relative to the fluid tip 70 and the tubular member 46 and tubular  
member 58 of the concentric tube assembly 16. Convergent cap 120 is  
frictionally fitted or fitted in any suitable manner at the aft end of the dry

powdered nozzle cap 14 and includes a nozzle 122 defined by the convergent  
cap 120 that directs the flow of dry powder from the dry powdered nozzle 14  
into the plume A ( as shown in Fig 3). The annular space between the sleeve  
116 and the inner diameter of the main body 102 of the dry powdered nozzle  
14 define an annular manifold 116 where the powder is transmitted and  
streamlined just prior to being injected into the low pressure zone of the  
atomized plume A (Fig. 3). These elements just described, namely the air cap  
92, fluid tip 70 and dry powdered nozzle 14, form the end-effector of the  
convergent spray gun. While the end-effector of the present invention  
functions similarly to the end-effector shown in Patent No. 5,307,992, supra,  
because of the incorporation of the concentric tube assembly 16, the dry  
powdered nozzle 14 and convergent cap 120 is made significantly smaller than  
the heretofore designs while at the same time being comparable to the volume  
of flow of the ingredients emitted at the discharge end of the spray gun.

Fig. 6A exemplifies another embodiment of the dry powdered nozzle  
14a that includes the central passage 200 (the same reference numeral with  
a subscript is used to depict similar parts in all the Figures) for flowing the  
liquid resin that discharges through central orifice 202, the annular air  
passages 206 that discharge the air through the annular orifice 210 at an angle

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to converge with and atomize the resin and the diametrically opposed dry  
a powdered passages <sup>215</sup>~~212~~ and <sup>219</sup>~~214~~ that directly feed into the low pressure zone  
<sup>215</sup> <sup>218</sup>  
of the plume of the atomized air/resin stream. It will be appreciated that the  
configuration of the dry powdered nozzle 14 depicted in Figs. 5 and 6 is  
5 designed to accommodate the larger granular sized particles of dry powder,  
while the dry powdered nozzle 14a depicted in Fig. 6A is preferably designed  
for a finer dry powder granular.

In operation, and as seen in Fig. 7, suitable commercially available  
hose 124 interconnects the spray gun 10 to the high pressurized air source  
10 134 via the receiving box 18. The powder and low pressure air for  
transporting the same is represented by box 136 which is also transported to  
the spray gun 10 via receiving box 18 where it is split and transported to the  
dry powder nozzle 14 or 14a. The static mixture 138 (which may be a suitable  
Hirsch tube) that supplies the resin (which in this embodiment is made from  
15 two components, resin and catalyst) to the spray gun 10 via line 128. The  
catalyst and resin are admitted into mixer 138 from manifold 143 which  
receives these components through lines 139 and 141, respectively. A  
proximity switch 146 may be added and connects with the shut-down system  
148 which is the subject matter of the co-pending patent application

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mentioned in the Cross-Reference of this patent application.

The miniaturized gun 10 is sufficiently small and light in weight so as to be easily handled by a user much in the same manner that a commercially available powered paint spray gun is used. Actuation of the trigger 30 simultaneously opens and closes valve 24 and turns on the computer, valves, proportioning devices, pneumatic devices, for flowing and stopping the flow the ingredients being delivered to the gun. A solvent in reservoir 151 is admitted into the resin flow lines via the mixer 138 via line 147 and a suitable on/off valve 149. The solvent is admitted into the manifold 143 and flows through the resin lines in the gun to assure that the resin that is captured therein when the gun is shut off doesn't cure and become hardened.

As mentioned in the above-paragraphs the volume of ingredients emitted from the gun corresponds to the larger and heavier convergent spray guns that are known. The spray gun made in accordance with this invention also is not only capable of being hand-held but is also capable of applying thermal protection coatings with the absence of a solvent, and is compatible with epoxy, polyurethane, silicate, water based or 100% resin systems, and has the capability of controlling the thickness and the dimensions of the area of the applied coatings, has the ability to control both dry filler and resin filled

material independently, to apply the coatings to smaller parts and enclosures and is capable of reducing the number of passes to attain the desired thickness of the coating, while at the same time reduce the amount of hazardous materials and solvents while being capable of controlling density.

5           Fig. 8 exemplifies another version of this invention and is a prototype of a modified robotically held spray gun that is miniaturized so as to be capable of being hand-held similar to the version depicted in Figs. 1-7 and is available for a portable system. The spray gun generally illustrated by reference numeral 160 which as mentioned above is a prototype of a spray  
10   gun cobbled up from a robotically held spray gun and is miniaturized for hand-held operation or for a portable system and includes a modified Binks gun 162 that is commercially available, an air motor 164, a paddle mixer 166 and the concentric tube assembly 168, the fluid tip 70 (like reference numerals used in all the Figures depict like or similar elements), air cap 90, and the dry  
15   powdered nozzle 14. As noted in the version depicted in Figs. 1-7 instead of the static mixer upstream of the spray gun 10 being utilized, in this version a paddle mixer 166 is utilized, noting that either version of the spray guns may  
a   utilized either type of mixer. The paddle mixer 166 <sup>is</sup> ~~is~~ driven by the air motor of the Binks gun which is powered by the pressurized air flowing into

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the gun through inlet 170 and discharging through the outlet 172 and mixes the resin (double type) fed thereto through inlet fittings 174 and 176. The mixed resin after being acted on by the paddled mixer 166 flows through the housing 178, cross-over tube 180 and into the inner tubular member 182 and  
5 discharges through the central orifice 26 formed on the end of the fluid tip 70. Air cap 90 that fits over the fluid tip 70 receives pressurized air from the inlet 182 and flows through inner passages formed in the housing 178 into the cross-over tube 184 and into the annular passage formed between the inner diameter of outer tubular member 186 and the outer diameter of inner tubular  
10 member 182. The dry powdered nozzle 14 fits over the end of the reduced diameter portion of outer tubular member 186 and injects the dry powder from the manifold and convergent cap 120 into the wetted resin atomized  
plume A (similar to Fig. 4). The spray gun operates in much of the same way as the version in Figs. 1-7, where the operator depresses a suitable switch that  
15 actuates the system of valves, proportionate devices, eductors, pneumatic conveying equipment controlled by the computer which turns the system on and off. Turning the system on flows the proper proportion of resin, dry powder, atomizing air and pressurized motor air to the gun 160 for actuating the paddle mixer 166 and the valves in the gun to generate the atomized

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convergent plume of wetted resin and drive the dry powdered nozzle to inject the dry powder into the plume in the manner described in connection with the spray gun depicted in Figs. 1-7.

5 The version of the spray gun exemplified in Fig. 9 is a combination of the elements that constitute the spray gun depicted in Figs 1 and 8, where the Binks gun and Paache tubes are modified to miniaturize the spray gun. Obviously, because the handle takes the elongated shape rather than the pistol shape, the spray gun is better suited for use with the robot. However, since the parts are miniaturized, the spray gun is more appealing to be used in a  
10 portable spray system rather than the separate room arrangement that is typical for this type of coating application. In the Fig. 9 version the spray gun utilizes a commercially available Binks gun 162a with all of the same flow passages for the air and resin and includes a similar paddle mixer 166a. This Binks gun is modified to include an air conduit 220 that interconnect the air  
15 passage in the Binks gun with a manifold 224 that is mounted on the end of the paddle mixer 166a. The manifold directs the air around the resin without co-mingling therewith and flows in the outer tube of the the double tube configuration 16a. This portion of the gun is virtually identical to the forward portion of the spray gun depicted in Figs. 2, 3 and 4 and reference should be

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made thereto for details of the components thereof. The unit comprises the double concentric tubes 16a for passing the resin and air to the discharge nozzle of the spray gun through the fluid tip element 70a and into the air cap 90a. The sleeve 116a that fits over the double concentric tubes 16a, fluid tip element 70a and air cap 90a accommodates the dry powder nozzle 14a for passing the dry powder into the atomized air/resin stream discharging from the tip of the spray gun. Like in the other spray gun versions the dry powder nozzle configuration depicted in Fig. 6A can be substituted for the dry powder nozzle 14 depicted in this embodiment.

Although this invention has been shown and described with respect to detailed embodiments thereof, it will be appreciated and understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

It is claimed:

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